

PROVENANCE VARIATION IN GERMINATION AND SEEDLING GROWTH OF *Rhododendron ponticum* L.

VARIJABILNOST PROVENIJENCIJA U KLIJAVOSTI SJEMENA I RASTU SADNICA VRSTE *Rhododendron ponticum* L.

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SUMMARY

Rhododendron ponticum is a popular shrubby plant in landscape architecture planting designs. It is especially effective when used in large groups, due to its form, foliage and flower aesthetics, as well as its functional properties. The plant is indigenous to many mountainous and forested areas of different elevations. In the present study, the germination success of *Rhododendron ponticum* seeds obtained from three different provenances in NE Turkey: Zafanos (39°46'N, 40°56'E, 592m), Maçka (39°39'N, 40°41'E, 1234m) and Zigana (39°24'N, 40°39'E, 1744m) was investigated under greenhouse conditions (25 ± 2°C, 70 ± 2% Humidity). After germination, seedling sizes and root length were determined. The highest germination rate (78.91%) was obtained with the seeds collected from Maçka (1234m). The development of the seedlings demonstrated that the greatest height and root length values were obtained with the seedlings collected at the Zafonos site (592m). It was found that germination success was not effectively correlated with the rate of seedling development.

KEY WORDS: *Rhododendron ponticum*; germination; seedling growth; provenance variation

INTRODUCTION

UVOD

The genus *Rhododendron* of the *Ericaceae* family contains over 600 species (Cross, 1975). It is a shrubby plant with many aesthetic qualities, such as having fragrant, brightly-colored flowers in many different colors blossoming at different periods, beautiful autumn colors and attractive foliage.

The natural habitat of *Rhododendron* is generally the mountains, where the climate and soil conditions are most suitable for the growth of *Rhododendron* and result in its prevalence around the world. This terrain can be characterized by abundant rain and cool-temperate to cold temperatures

(Reiley 1995). The most common *Rhododendron* habitats include the southernmost upland parts of Asia (Coombes 1998), much of Northern Europe and North America, and they occur extensively in China and the Himalayas. They are also found in the southern Black Sea area, the southeastern corner of the Caucasus, northeastern Turkey and southeastern Bulgaria, as well as in Lebanon, Southwest Spain and Central Portugal (Jessen *et al.* 1959; Cross 1975; Davis 1978).

The *Rhododendrons* often have shallow roots. The roots beneath the organic foliage layer also develop with the materials in the soil layer outside the soil and demonstrate a rapid and broad growth on the surface (Clarke 1982).

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Rhododendron ponticum, a common and widespread evergreen species of the *Rhododendron* genus, is 2–8 m long and has a vertical form. (Tutin *et al.* 1972) Its leaves are dark green and oblong-elliptic (Cross 1975). The funnel-shaped flowers are purple, lavender and pink (Burnie *et al.* 2004).

The thick leaf-litter layer created by *Rhododendron* on the forest ground breaks down slowly in some areas and may therefore endanger the natural bushes and trees by occlusion, and thus may result in a new or more restricted surface vegetation (Cross 1975). Studies in the literature indicated that *Rhododendron ponticum* is an invasive species on mixed forest ground, particularly in oak and beech forests and also investigated the measures against *Rhododendron ponticum* invasion (Thomson *et al.* 1993; Erfmeier and Bruelheide 2004; Esen *et al.* 2004; Tyler *et al.* 2006; Harris *et al.* 2009).

Despite its damage to the endemic forest vegetation where it is an invasive species, *Rhododendron ponticum* has an aesthetic value in landscape architecture due to its evergreen foliage and the purple and mauve tinted flowers that blossom in the spring. They are particularly effective when used in groups. In planting designs, in addition to their aesthetic effects, they can be utilized as hedges and border elements to create stimulant effects in slope stabilizations and roadway planting.

The present study aimed to support the seed cultivation of *Rhododendron ponticum* for its use in landscape planting designs. In this context, the success of germination of seeds obtained from different elevations was investigated.

MATERIALS AND METHODS

MATERIJALI I METODE

Rhododendron ponticum L. seed capsules were collected in November 2015, in the maturation season, from the origins at different altitudes in the Eastern Black Sea region in Turkey. Bulk seeds for each origin from at least 30 species were used. Information on the origins of the plants where the *Rhododendron ponticum* seed capsules were collected is presented in Table 1.

Seed capsules of *Rhododendron ponticum*, collected from different, were spread in a thin layer in the laboratory and dried at ambient temperature and humidity. Dried capsules were manually broken open and the seeds were removed. Before the seeds were sowed, it wasn't applied any treatment for seeds to determine their viability, only healthy seeds were chosen. One thousand seed weights were determined using randomly selected seeds. The seeds were separated according to their origins in closed containers. Cold stratification pre-treatment at 2–4 °C in dark conditions was applied to the seeds for 3 months until February 2016 before sowing.

Germination experiments of *Rhododendron ponticum* seeds were conducted in the greenhouse with technological systems at 25 ± 2 °C, $70 \pm 2\%$ humidity conditions. Soil, Peat, Soil + Sand (5:5), Soil + Sand (7:3), Peat + Sand (7:3) and Soil + Peat + Sand (4:4:2) media were prepared for germination in the study. Afterwards 3 x 100 seeds were planted in planting crates in the greenhouse in three repetitions for each elevation. The crates were covered with a polyethylene cover to provide suitable moisture until the germination process is completed.

Irrigation operation was conducted with the sprinkling method and equal amounts of water were provided for each crate. Weeds were removed from the medium during the study.

From the first day of germination, germinated seeds in each medium were counted at one-week intervals. At the end of the study after eight months of sowing in October 2016, measurements were conducted to determine the height and root length of the seedlings in the medium, based on the elevation they were obtained from during the diversion of the germinated seeds. The seedling height and the length of roots formed were measured as three repetitions by a type measure at 1 mm sensitivity and recorded as "cm".

In the present study, multivariate analysis of variance was conducted to reveal the differences between the germinated seeds based on the altitude of collection and germination medium and the values obtained in the conducted measurements. Homogeneous subgroups were determined with the Duncan test. SPSS statistical software was used to conduct these analyzes.

RESULTS AND DISCUSSION

REZULTATI I RASPRAVA

Randomly selected 8x100 seeds were weighed on a precision scale and 1000 seed weight was determined (ISTA 1996). Seeds collected from Zafanos provenance (592m) weighed 0.0764g, from Macka provenance (1234m) weighed 0.09444g and from Zigana provenance (1744m) weighed 0.0805g (Table 1). Cross (1975) states that *Rhododendron ponticum* produces hundreds of thousands of seeds every year with an average weight of 0.063g. Small seed size also increases plant proliferation potential by allowing seeds to spread over long distances (Higgins *et al.* 1996; Rejmanek and Richardson 1996).

Gutterman (1992) notes that seed germination is affected by environmental factors, such as light, temperature and salinity conditions, as well as the origin of the seed. Differences between germination of seeds based on provenance were reported in many species (for examples, see Vera 1997; Keller and Kollmann 1999; Andersen *et al.* 2008; Singh *et al.* 2004; Vecchio 2012).

Table 1. The provenances of *Rhododendron ponticum* seeds and 1000 seed weighsTablica 1. Provenijencije sjemena *Rhododendron ponticum* i težina 1000 zračno suhijh sjemenki

Provenances Provenijencije	Altitude (m) Nadm. visina (m n.v.)	Latitude Geogr. širina	Longitude Geogr. duljina	Weight of 1000 grains (g) Težina 1000 zračno suhijh sjemenki (g)
Zafanos	592	039°46.135	40°56.663	0,0764
Macka	1234	039°39.392	40°41.133	0,0944
Zigana	1744	039°24.919	40°39.964	0,0805

Table 2. Germination rates of *Rhododendron ponticum* seeds collected from different provenances and altitudesTablica 2. Klijavost sjemena vrste *Rhododendron ponticum* sakupljenog iz različitih provenijencija i nadmorskih visina

Provenances Provenijencije	Altitude (m) Nadm. visina (m n.v.)	Germination rate (%) Klijavost (%)	F	Sig.
Zafanos	592	59,47 ± 7,25 a	567,773	0,000*
Macka	1234	78,91 ± 8,58 c		
Zigana	1744	68,64 ± 10,46 b		

*Significant at 0.01 level

*Značajno na razini 0.01

In the present study, significant differences ($P < 0.01$) were obtained between the germination data according to the results of the conducted analysis of variance. Duncan test findings demonstrated that three different germination groups were formed based on origin altitudes. The highest germination (78.91%) was observed in the seeds collected from Mačka provenance (1234 m) and the lowest germination value (59.47%) was observed in seeds obtained from Zafanos provenance (592 m) (Table 2). Given the seed weights, the highest rate of germination was determined in seeds collected from the Mačka provenance, with a maximum weight of 1000g (0.0944g). This suggests that a higher seed weight may promote germination. However, Vera (1997), in a study conducted with *Calluna vulgaris* and *Erica cinerea* seeds collected at different altitudes, noted that *Calluna* seed

size did not affect germination and there were no significant differences between the germination of different sizes of *Erica* seeds. It was reported, however, that the highest germination rate was obtained with the seeds collected at higher altitudes. In a similar study conducted with *Rhododendron catawbiense* seeds collected from five different provenances, it was reported that seeds collected from the highest altitude had higher cumulative germination under different light and temperature conditions (Rowe *et al.* 1994).

The germination rates of *Rhododendron ponticum* seeds collected from different provenances at different altitudes in six different media are presented in Figure 1.

The germination rates of *Rhododendron ponticum* taxa demonstrated that the highest germination rate (89.33%) was

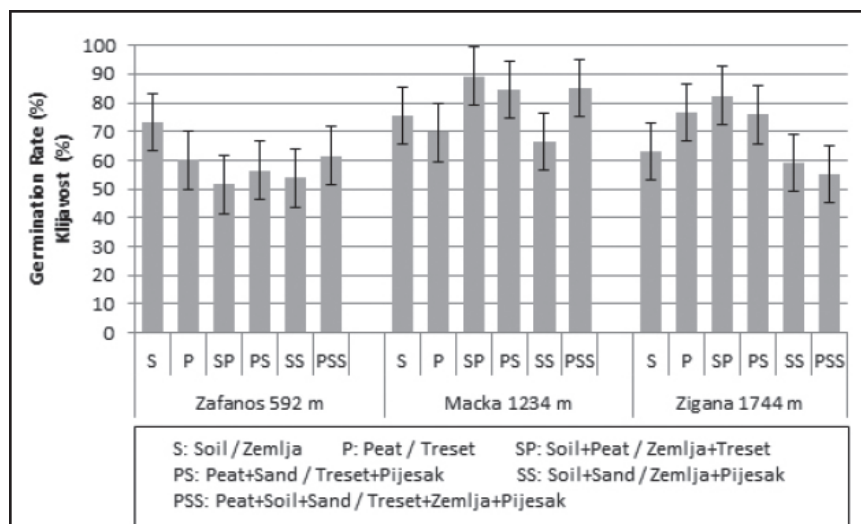
**Figure 1.** The germination rates of *Rhododendron ponticum* seeds collected from different provenances in different mediaSlika 1. Klijavost sjemena vrste *Rhododendron ponticum* različitih provenijencija u različitim supstratima

Table 3: Post-germination seedling height and root lengths of *Rhododendron ponticum* seeds collected from different provenances and altitudes

Tablica 3. Visina sadnica i duljina korijena nakon klijanja sjemena *Rhododendron ponticum* sakupljenog iz različitih provenijancija i nadmorskih visina

Provenances Provenijancije	Altitude (m) Nadm. visina (m n.v.)	Height (cm) Visina (cm)	Root length (cm) Duljina korijena (cm)
Zafanos	592	6,91 ± 3,20 b	6,13 ± 1,53 c
Macka	1234	5,09 ± 1,41 a	5,25 ± 1,35 a
Zigana	1744	5,33 ± 1,48 a	5,70 ± 1,55 b
F		86,272	12,713
Sig		0,000*	0,000*

* Significant at 0.01 level

* Značajno na razini 0.01

found in seeds collected from Mačka provenance at 1234 m in Soil + Peat (SP) growth medium. While the seeds collected from Zigana provenance at 1744 m also had a high germination percentage of 82.5% in Soil + Peat (SP), the seeds collected from Zafanos provenance (592 m) was determined in Soil (S) medium with a high germination percentage of 73.1%. *Rhododendrons* typically exhibit their best growth in forest soil and in soils with rich organic matter (Clarke 1982; Reiley 1995; Brenzel 1997). A similar study conducted with *Rhododendron ponticum* also demonstrated that the survival rate of the seedlings was better in soil rich in organic matter (Var and Dincer 2006).

Based on the analysis of variance results, seedling plant and root length values were statistically significant ($P < 0.01$). The seedlings developed from the seeds collected from Zafanos provenance at 592 m exhibited a higher size and root length when compared to the seeds collected in other provenances (Table 3). Plant height and root lengths of the seedlings from the seeds collected from high altitudes were determined lower. Similar results were obtained in a study conducted with *Carpinus betulus* seeds collected from different populations in different altitudes. It was reported that the lowest seedling heights developed from seeds obtained from populations at high altitudes (Hatipoglu 2013).

The maximum seedling height (6.91 cm) was observed in seeds collected at Zafanos provenance, however there were no significant differences between the seedling sizes of seeds collected from Macka and Zigana provenances, which both had high altitudes. When the length of seedling roots was examined, it was observed that there were three different groups. The seeds with the highest weight of 1000g and that demonstrated the most successful germination, that is, those collected from the Macka provenance at 1234 m, provided the lowest seedling height and root length. *Rhododendrons*, whose natural habitats are generally the mountainous, have higher seed weight and germination success at higher provenance. However, outside the growing areas,

these seedlings developed at lower altitudes, had lower height and root length. At the same time it was determined that the seedlings from Zafanos provenance at 592 m, with the lowest seed weight and germination success, had the best height and root development. It was found that seed weights and germination success were not positively correlated with the seedling size and root development.

CONCLUSIONS ZAKLJUČCI

Rhododendron ponticum, a shrub that offers unique attributes in planting schemes due to its form, foliage and flower properties could be effective in many areas in addition to its aesthetical properties. Due to their visual and functional qualities, they are among species that need to be cultivated and propagated, and their use in landscape architecture planting designs should be promoted. In the present study, the effect of different provenances on germination in *Rhododendron ponticum* seed cultivation was investigated and it was determined that seeds from high altitudes possessed greater germination success. In addition, germination in soil and peat media has been more successful. Although the germination success of high altitude seeds is high, it should be taken into consideration that seedling height and root lengths are not better.

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SAŽETAK

Rhododendron ponticum je popularna grmolika biljka koja se vrlo često koristi u krajobraznoj arhitekturi. Zbog svojega oblika, lišća i cvjetova, kao i zbog funkcionalnih značajki, posebno je efektivna kada se sadi u velikim grupama. Ova prirodna biljka raste u mnogim planinskim i šumskim područjima na različitim visinama. U ovome radu istražili smo uspjeh klijanja sjemena *Rhododendron ponticum* u stakleničkim uvjetima (25 ± 2 °C, $70 \pm 2\%$ vlažnost). Sjeme smo pribavili iz tri različita lokaliteta u sjeveroistočnoj Turskoj: Zafanos ($39^{\circ}46'N$, $40^{\circ}56'E$, 592 m n.v.), Mačka ($39^{\circ}39'N$, $40^{\circ}41'E$, 1234 m n.v.) i Zigana ($39^{\circ}24'N$, $40^{\circ}39'E$, 1744 m n.v.). Nakon klijanja određene su visine sadnica i duljina korijena. Najveća klijavost (78,91 %) utvrđena je kod sjemena sakupljenog u lokalitetu Mačka (1234 m). Razvoj sadnica pokazuje da su najveće vrijednosti visina i duljina korijena dobivene kod sadnica iz lokaliteta Zafanos (592m). Utvrđeno je da postotak klijanja nije u značajnoj korelaciji s rastom sadnica.

KLJUČNE RIJEČI: *Rhododendron ponticum*; klijavost; rast sadnica; varijabilnost provenijencije